

Waste to Energy at SUNY Cobleskill



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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OUTLINE



- Overview on Army Net Zero Concepts
- Gasification Intro.
- SUNY Cobleskill Center for Environmental Science and Technology.
- TURNW2E™ Gasification Technology Prototype.
- Modeling impact of Feedstock moisture on gasifier efficiency.
- Conclusions and Future Work.





ARMY NET ZERO VISION



The primary goal is a focus toward net zero and when we talk about net zero, it's not only net zero energy, but it's net zero energy, water, and waste. When you look at the term "net zero" or a hierarchy of net zero you must start with reduction, then progress through repurposing, recycling, energy recovery, disposal being the last.

--Ms. Katherine Hammack, DoD Bloggers Roundtable, 10 October 2010





Net Zero Energy



Net Zero Water



Net Zero Waste



ASOA. Net Zero White Paper.14Dec,2010



ARMY ZERO FOOTPRINT BASE CAMP



AERTA Zero Footprint Base Camp

Army Sustainment Programs - Renewable Portfolio Development

- •Wind
- •Solar
- •Water
- Waste to Energy



USMC ExFOB
Photo by: MAJ. Paul Greenberg, USMC. Marines. mil



Waste at FOB

- Logistical/Security
- Environmental Hazard



Photo: Kelly Kennedy, Army Times. 20Nov. 2008



GASIFICATION A TECHNOLOGY 2-fer



Waste Reduction



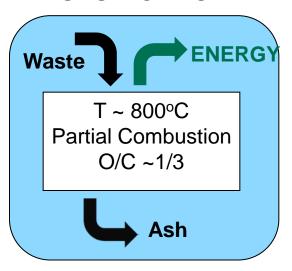
- Reduced Logistics for Waste Transportation
- Reduced environmental and personnel impact

Energy Production



- Reduced Fuel Usage for transportation
- Increased Energy independence of Base Camps

GASIFICATION







THEN & NOW



- **1800's** Produced syngas Used to for town lighting and fuel.
- **1860's** Siemens' introduced "first" successful commercial unit.
- WWII Shortages of petroleum led to ~
 9MM vehicles being powered by wood gasifier engines (gasogenes) in Europe.
- **Post War** Interest largely died off due to surplus of petroleum.
- Now Interest in reducing waste and dependence on fossil fuels has led to rejuvenation of gasification technologies. Especially in wastestreams for fuels.

Australian "car" powered by Charcoal-gasifier 1939



Off-the-grid livin!





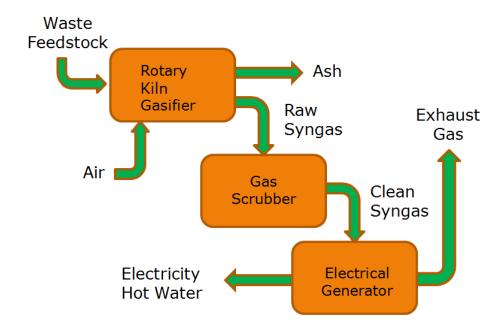


GASIFICATION



- Pyrolytic process of converting any material (feedstock) that burns into a fuel gas (syngas).
- Operates in an oxygen starved environment, creating H2, CO, and small amounts of CH4 as flammables.
- Syngas can be used to operate various combustion based equipment including boilers, gas turbines, and I/C engines.

Overview of Cobleskill Rotary Kiln Gasifier







SUNY Cobleskill Center for Environmental Science and Technology





The TURNW2E™ Gasification
Technology Prototype, supplied by
W2E Ventures, Inc., will be installed at
the new Center for Environmental
Science and Technology at SUNY
Cobleskill.

SUNY Cobleskill CEST

- Completed in early 2011
- 14,000 sq. ft. facility
- Research Labs
 - Biowaste-to-bioenergy
 - Chemistry
 - Engines/physical
- New Bachelors in Environmental and Energy Technologies

CEST MISSION

- Reduce society's dependency on fossil fuels.
- Research conversion of biomass and agricultural waste materials to clean energy.
- Train the next generation of leaders in agricultural science and technology to 'think green'





Installation of System





Kiln being delivered to CEST



Kiln located in CEST

- Delivery began end of April
- Scheduled completion date early June



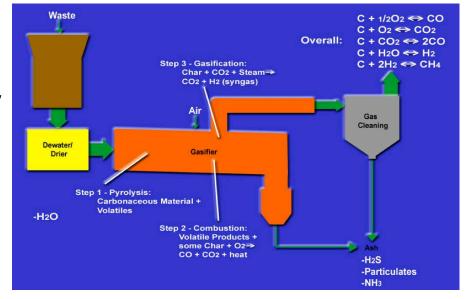


Cobleskill Gasification Kiln



Desired Outcomes of Project

- Capable of processing a multitude of waste streams
- Self-sustaining "net-energy producer"
- 100kW output capable of running gensets at reduced JP8 usage.
- > 50% efficiency in conversion of bio-waste to producer gas.
- Easily containerized and deployable





Processing a Multitude of Waste Streams



Feedstocks to be addressed

- Paper
- Wood
- Food wastes
- Mixed plastics (common container resins plus PVC)
- Dewatered human waste
- Combustible materials with fire retardants (tents, uniforms, etc.)
- Light construction materials
- Motor pool lubricants, off-spec fuels
- Tires
- Medical wastes
- Non-flammable inert

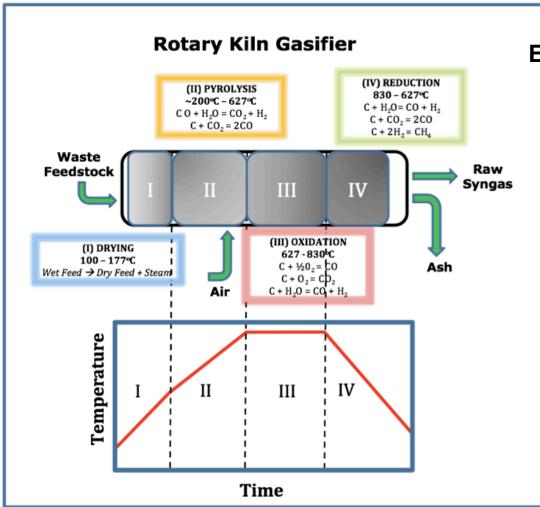
- Many waste materials have excessive moisture.
- Moisture creates a significant heat load, reducing reaction temperatures.
- > 1600 F is essential to fully remove volatile matter and thermally crack tars.
- Common practice is to dry the feedstock prior to gasification.
 - · Adds complexity to design





Equilibrium Modeling of Gasification





Equilibrium is rarely reached

- Residence times
- Low Temp
- Side Reactions

Equilibrium is a good start

- Predict changes to performance
 - Residence times
 - Low Temp
 - Side Reactions

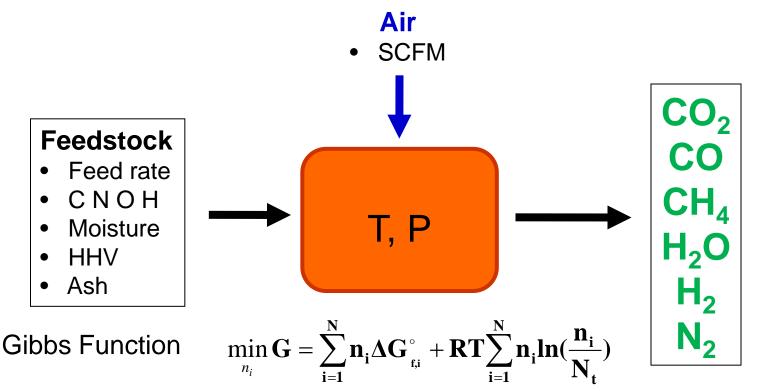




Our Model



$$AC_xN_vH_zO_k \bullet BH_2O + C(O_2 + 3.8N_2) \rightarrow \alpha CO_2 + \beta CO + \chi CH_4 + \delta H_2O + \varepsilon H_2 + \phi N_2$$



Mass Balance (constraints) $\mathbf{N}_{j} = \sum_{i=1}^{N} \mathbf{a}_{ij} \mathbf{n}_{i}$ (j = 1,...,O)





Down Draft Unit for Testing



Currently utilizing small "cheaply built" Down-draft unit for testing and evaluation.



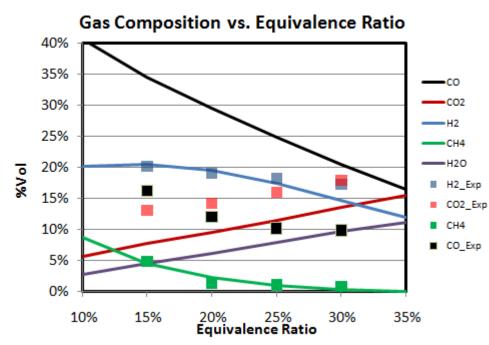




Equivalence Ratio & Gas Quality



 $T = 1500^{\circ}C$



FEEDSTOCK					
Analyte	wt%				
С	51.5				
Н	5.7				
N	0.35				
0	41				
H2O	5				

Errors	likely	due to:
Fauilibi	rium n	ot beina

rium not being reached Heat Losses, inefficiencies in gasifier

Experimental								
Compound	Result	15%	20%	25%	30%			
H2	Exp.	20.20%	19.10%	18.30%	17.30%			
	Equil.	20.60%	19.51%	17.46%	14.81%			
	%Error	1.98%	2.15%	-4.59%	-14.39%			
CO2	Exp.	13.10%	14.20%	16.00%	18.00%			
	Equil.	7.73%	9.62%	11.56%	13.59%			
	%Error	-40.99%	-32.23%	-27.74%	-24.48%			
со	Exp.	16.30%	12.10%	10.20%	9.90%			
	Equil.	34.60%	29.52%	24.92%	20.49%			
	%Error	112.24%	143.95%	144.27%	107.01%			
CH4	Exp.	4.90%	1.40%	1.10%	0.90%			
	Equil.	4.63%	2.28%	1.01%	0.38%			
	%Error	-5.58%	63.03%	-8.18%	-57.28%			

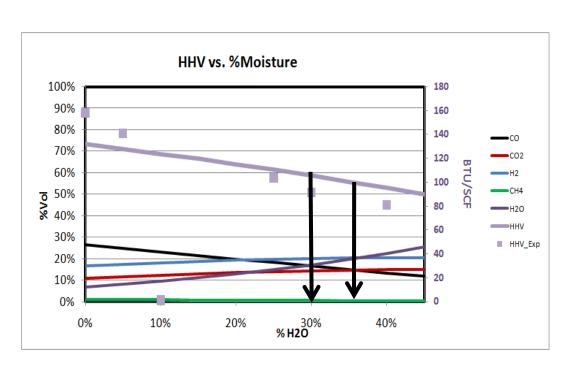




Water Content and Gas Quality



Max Moisture 30% @ 1500°F



- Feedstocks can be mechanically pressed to reduce the moisture within the acceptable range without drying.
- Design gasifier to operate at the highest thermal efficiency to maximize gas heating value.
- Possible to gasify wastes with moistures up to 30%, at maximum efficiency, with high reaction temps, and with minimal tar.





Conclusions



- Rotary Kiln Gasifier to be installed this summer.
- Several Problems answered using downdraft as model.
 - ER =0.25 0.30 and T = 1500°F to minimize Tars and maximize thermal cracking.
 - Max Moisture of Feed 30% w/o outside drying.
 - Possible use of mechanical drying to save energy.







QUESTIONS





Future Work



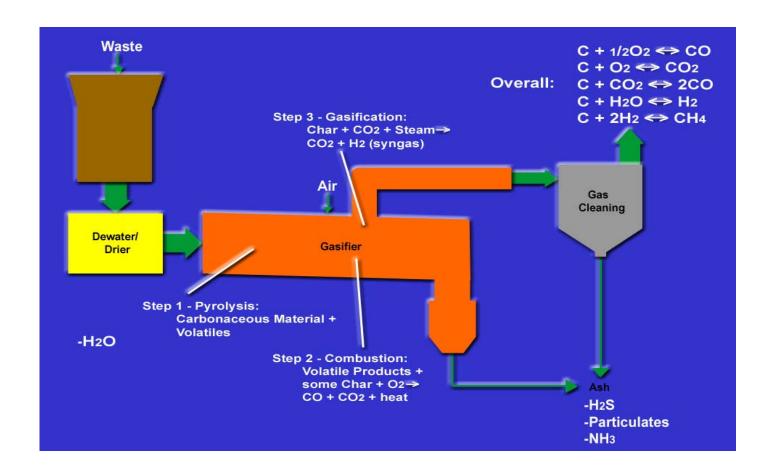
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Rotary Kiln Gasification









Gasification Syngas Outputs



- Product outputs (depending on chamber temperature)
 - Syngas
 - Char
 - Steam
- Syngas clean up outputs
 - Hydrogen
 - Carbon Monoxide
 - Ash
 - Nitrogen
 - Sulfate
 - Precipitates





System At SUNY COBLESKILL





W2E USA, Inc. ®





Equilibrium Modeling of Gasification



Oxidation Reactions:

$$C + 1/2O_2 \rightarrow CO$$

$$CO + 1/2O_2 \rightarrow CO_2$$

$$C + O_2 \rightarrow CO_2$$

Boudouard Reaction:

$$C + CO_2 = 2CO$$

Water Shift Reaction:

$$CO + H_2O = CO_2 + H_2$$

Methane Reaction:

$$CH4 + H_2O = CO + 2H2$$

Given a set of K...simultaneously solve for the equilibrium concentrations.

Scale of modeling using reaction equilibriums make this a daunting task



Potential Future of Gasification



- Convert Waste to Hydrogen
- Convert Waste to Liquid Fuels
 - Use As Is

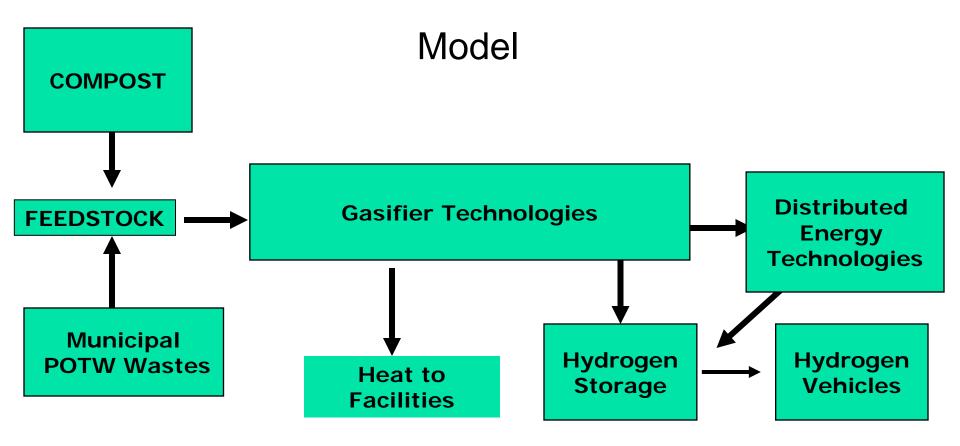






Army Deployment for Installations









ENHANCED SYSTEM BENEFITS



- Vessel Composter will provide an instant payback for the system as well as benefits for Morale Welfare Recreation (MWR) programs
 - Gives extra incentive on financial issues
 - Compost could be sold to increase payback
 - Would enable tree and shrub wastes from local communities
 - Extends Landfill life
 - Reduces cost to local communities by waste diversion
- Addition of the Composter will provide a steady state fuel for the gasifier
 - This will effectively provide a level of performance with minimal peaks and valleys
 - Will reduce risk





What Differentiates Cobleskill from other Gasification Systems



- Rotary kilns can gasify a wide variety of feedstock shapes and sizes (large chunks to fines).
- Direct flaming pyrolysis, ash is produced as the final product, not charcoal.
- Gasify using air to avoid the need for an oxygen generating plant.
- Kiln rotation naturally agitates the waste, eliminating blockages.
- High operating temperatures thermally crack tars into additional gas.

